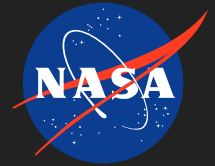


# Turbulence, gravity waves, and instability dynamics observed in polar mesospheric clouds

Completed Technology Project (2016 - 2019)



## Project Introduction

The proposed research would address small-scale gravity wave, instability, and turbulence dynamics that play central roles in the transport and deposition of energy and momentum throughout the atmosphere. These dynamics are key to defining the large- and smaller-scale structure and variability of the MLT, and their neutral and ionospheric influences extending to higher altitudes. Despite their importance, and numerous previous studies, these dynamics are poorly understood at present. Multiple rocket and ground-based studies have provided important advances defining larger-scale environments and gravity waves, the types and scales of instabilities, and measures of the intensity and variability of turbulence at smaller spatial scales. However, no previous experiment has simultaneously defined 1) the spatial context of the driving gravity wave and instability dynamics over extended horizontal scales, 2) the transition from larger-scale instabilities to turbulence, and 3) the evolving instability and turbulence character extending to the turbulence "inner" scale continuously in time throughout the event. Serendipitous imaging of small-scale instability and turbulence structures in polar mesospheric clouds (PMCs) by star cameras supporting the EBEX stratospheric balloon experiment has demonstrated the potential for such observations. These images reveal instability and turbulence dynamics extending from a few km to  $\sim 10$ -20 m scales (pixel resolution of 3 m) and offer a new window on these dynamics that were not previously possible with any measurement technique. The keys to this sensitivity lie in the very thin PMC layer brightness where advection causes strong PMC thinning and imaging from above atmospheric turbulence at lower altitudes. Our proposed experiment would expand PMC imaging capabilities spatially and temporally. New imaging using very-high-resolution (50 Mpixel) detectors and co-aligned wide and narrow fields of view (FOV) would extend horizontal spatial coverage from  $\sim 100$  km to  $\sim 10$ -m scales with imaging resolution as high as 2 m. A fixed anti-sun viewing platform would allow tracking of entire events throughout their evolution extending many buoyancy periods (e.g., an hour or longer) with 2-s resolution. High-resolution modeling of gravity wave, instability, and turbulence dynamics that has already yielded tantalizing comparisons of simulated and observed dynamics would be employed to guide quantification of the observed events. The flight program would utilize a small or mid-size constant-pressure balloon flown from McMurdo Station, Antarctica for a flight of 1-2 weeks allowing one orbit around the Antarctic vortex in Austral summer. A launch window from 15/12/2017 to 15/01/2018 would guarantee high sensitivity by our imagers to the multi-scale dynamics revealed in PMC imagery. The experiment would leverage EBEX imaging heritage, the proven CSBF solar power and course pointing systems, and electronics and software to minimize risk in cost and the development timescale. The entire payload would weigh  $\sim 1000$  lbs, facilitating a relatively simple and cost-effective launch. Minimum telemetry would be needed to evaluate imager performance during the mission, with data stored onboard until retrieval of the payload following the measurement program. The payload



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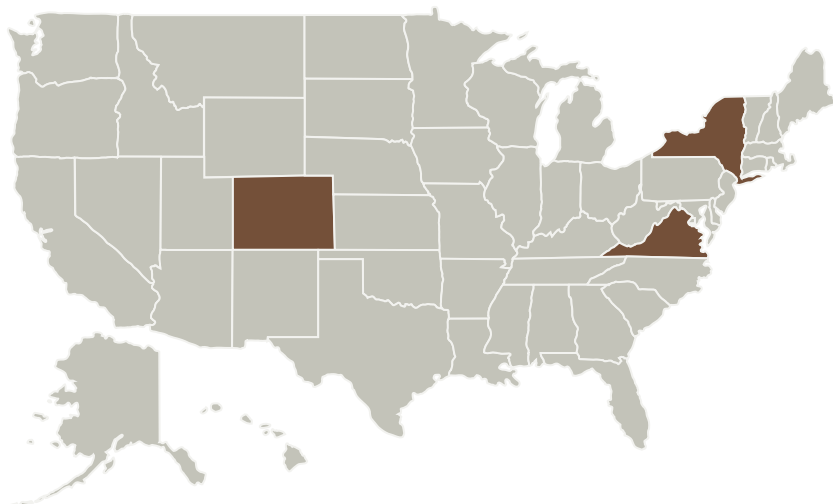
would be delivered to the NASA balloon facility in Palestine, TX for testing and shipping to McMurdo ~4 months prior to the anticipated launch window. The proposed research would have specific relevance to goals 2 and 4 in the recent Heliophysics Decadal Survey, Solar and Space Physics: A Science for a Technological Society: - Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs, - Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe.

## Anticipated Benefits

Support NASA's strategic objectives to understand the Sun and its interactions with Earth and the solar system, including space weather. This will be achieved by developing/demonstrating instrumentation technology necessary to address the following science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system;
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system;
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

## Primary U.S. Work Locations and Key Partners



## Organizational Responsibility

### Responsible Mission Directorate:

Science Mission Directorate (SMD)

### Lead Organization:

GLOBAL ATMOSPHERIC TECHNOLOGIES AND SCIENCES (GATS)

### Responsible Program:

Heliophysics Technology and Instrument Development for Science

## Project Management

### Program Director:

Roshanak Hakimzadeh

### Program Manager:

Roshanak Hakimzadeh

### Principal Investigator:

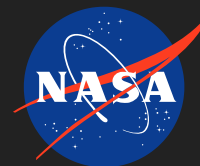
David C Fritts

### Co-Investigators:

Glenn Jones  
Della L Boscana  
Amber D Miller  
Michele Limon  
Bifford P Williams  
Ling Wang  
Jason Reimuller

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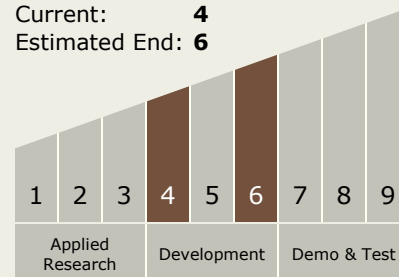


Organizations Performing Work	Role	Type	Location
GLOBAL ATMOSPHERIC TECHNOLOGIES AND SCIENCES(GATS)	Lead Organization	Industry	Newport News, Virginia

Primary U.S. Work Locations	
Colorado	New York
Virginia	

## Technology Maturity (TRL)

Start: **4**  
Current: **4**  
Estimated End: **6**



## Technology Areas

### Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.3 Optical Components

## Target Destination

The Sun